



PATENT

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November 8, 2005

John C. Hammar

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: J. Waldrop *et al.* Group Art 1732
Unit:
Application No.: 09/731,945 Examiner: Staicovici
Filing Date: Dec. 7, 2000 Docket No.: 99-113A
For: *Double Bag Vacuum Infusion Process*

Mail Stop Appeal Brief-Patents

Commissioner for Patents

P.O. Box 1450

Alexandria, VA 22313-1450

REPLY BRIEF

Sir:

Applicant files this Reply Brief within two months following the Examiner's Answer dated September 8, 2005. Applicant does not believe that a fee is due. If Applicant does owe a fee for filing a reply brief, please charge that fee to Deposit Account 18-1730. In addition, if Applicant owes any other fee (including any fees under §1.17 or all required extension of time fees), please charge that fee to Deposit Account 18-1730. Please treat this paper (and any future reply) as incorporating a petition for extension of time for the appropriate length of time, in the event that an extension is required.

1. REAL PARTY IN INTEREST

The real party in interest in this appeal is The Boeing Company, the assignee of the present patent application.

2. RELATED APPEALS AND INTERFERENCES

Applicant does not know of any other appeals or interferences involving this application or its subject matter.

3. STATUS OF CLAIMS

1. Claims pending: 1, 2, 4 - 8, 10 - 12
2. Claims canceled: 3, 9
3. Claims withdrawn from consideration but not canceled: 2
4. Claims allowed: None
5. Claims rejected: 1, 4 - 8, and 10 - 12.
6. Claims on appeal: 1, 4 - 8, and 10 - 12

4. STATUS OF AMENDMENTS

Applicant did not file an Amendment After Final Rejection in Response to the Examiner's Action dated March 18, 2005.

5. SUMMARY OF CLAIMED SUBJECT MATTER

As described in the Summary at page 11 to page 15 of the application and in greater detail in the Detailed Description, the present invention is a liquid molding process and system for producing quality composite structures at low cost. It falls within the category of resin transfer molding (RTM), particularly vacuum-assisted RTM (VaRTM). The simple tooling, minimal capital requirements, batch processing capability, high yield, and capability to mold complex shapes make the process attractive. For making aerospace structure, it promises to be an economical process, especially suited for large structures, including wing boxes and the like. The present invention dovetails nicely with other enabling technologies such as stitching, Z-direction reinforcement (Z-pinning), electron beam curing, 3-D weaving, and low temperature curing. It does not require an autoclave, matched tooling, or large presses.

High vacuum integrity with a double bag system (62 & 64, Fig. 2) of our design helps to yield high quality composites consistently with low void content, minimal surface porosity, excellent thickness control, and high fiber volume fractions. The double bag improves stiffness of the bagging material to avoid relaxation behind

the wavefront, thereby permitting the infusion of void-free composites having the high fiber volumes desired for aerospace applications. Controlling relaxation effectively means that we can use a higher differential pressure (DP) as the driving force for resin transfer. We can infuse faster or can use more viscous resins because of the larger driving force. We desire fiber volume fractions in excess of 50%.

Resin wave front control produces clean infusions without surface porosity, voids, dry spots, or resin rich zones. *Seemann* uses thick coarse flow media to direct resin to the underlying preform and bag offsets. The media and offsets create a highly permeable space for rapid resin migration laterally in the bag. The speed of infusion, however, can lead to trapped air or surface porosity defects or voids as the resin percolates down through the thickness of the preform. Lateral flow can exceed downward wetting of the preform, trapping air in pockets. Air trapped behind the wave front becomes difficult to remove from the infused part. Bubbling as air escapes can make it difficult to establish an end point for the infusion.

The key to successful infusions is not the speed with which the preform (51, Fig. 2) is infused, but rather the quality of the infusion. Maintaining a controlled wave front with lower permeability flow media over the preform gives cleaner infusions. The flow media (60, Fig. 2) we prefer to use should allow the resin to flow laterally slowly enough that the resin can uniformly drop down through the preform to wet out and completely fill the preform with a wedge shaped flow profile. In a controlled flow front, the resin front on the bag side of the preform is only 2 or 3 inches ahead of the resin front on the tool side of the preform assuming flow media is placed only on the bag side of the preform and infusion includes lateral flow through the media followed by downward flow to fill the preform. We prefer to control the relative permeability of the flow media to that of the preform to achieve this orderly, albeit relatively slow, infusion.

Our unique, open weave, TEFLON impregnated glass flow media (Taconic 7195) [60, Fig. 2] controls the flow front because it is thin, has modest permeability, and its fill fibers form flow weirs. Besides controlling resin flow, the media works to solve a number of other issues. This media can withstand exposure to temperatures up to about 600°F and is chemically inert. It is free of contamination and has excellent release properties. It is readily available, has relatively low foreign object defect potential, and minimizes bag bulk because

it is low profile. It reduces or eliminates mark off on the bag side of the laminate with its stiff but pliable nature.

One option to achieve improved flow control uses bagging materials 62 & 64 with high elongation (over 500 %) and relatively low modulus, such as STRETCHLON 700 polyester and STRETCHLON 800 nylon bagging films. High elongation bagging materials make it easier to bag simple and complex preforms with relatively few bag wrinkles. Preform areas under bag wrinkles tend to have relatively high permeability and can result in undesirable resin channeling along those bag wrinkles. Therefore, minimizing bag wrinkles with high elongation bagging materials improves flow front control.

Another option uses gum rubber seals around the periphery of the part. With no edge seal or solid edge seals, channeling often occurs at the edges of the preform because of the high permeability that exists in the gaps typically found between the preform, bag, and solid seal. Using high elongation bags and gum rubbers seals together with/or without thermal vacuum cycles, a tight seal between the edge of the preform, bag, and seals can be achieved. The gum rubber moves viscoelastically to fill in all the gaps that otherwise exist at the irregular edge of a dry or binderized preform (i.e., a preform having fibers coated with or containing binder or tackifier). Gum rubbers seals have been found to be particularly useful when dealing with thick preforms where one has large bag discontinuities at the edge of the part. Bag bridging at these locations allows excessive channeling. Gum rubber seals, however, work to seal the edge effectively, ease the bag transition, and reduce the effects of edge tapering on the preform from bag stresses.

A double ended vacuum pull off technique successfully defeats channeling that may occur for any number of reasons. If resin channels along one edge of the part, the potentially "fatal" problem can be simply corrected by clamping the vacuum tube on the channeled side and continuing the vacuum infusion with the opposite vacuum line in an active mode.

Another method proven to defeat channeling is to infuse preforms in an inclined orientation with the resin being fed at the lowest elevation and moving upwardly through the preform with vacuum through ports located at the highest

elevation. (Claims 11 & 12; Figs. 7 & 8 – flow of resin is into the base of the I-beam, up through the web to the top flange, and finally to the drop-out tube) With this method, gravity helps to maintain a constant fluid level in the preform and resists resin flow, at least partially. Some preforms, such as multi-axial warp knit preforms with bundled unidirectional fibers can have naturally occurring permeability variations that can cause poorer flow control than in preforms using more consistent materials such as 5 and 8 harness satin cloth.

A thermal vacuum cycle used prior to infusion also minimizes channeling. Here, the preform 51 gets debulked (i.e., compressed while having air removed from between plies) to a thickness within about 10 % greater than its final thickness. Likewise, the bag's modulus drops at elevated temperature where it more easily elongates. As the bag elongates, it fits better and better to the underlying preform material, eliminating all but the most severe of bag bridges. In cases of severe bag bridging, as for example at discontinuities around tooling elements for bag side stiffeners, we use gum rubber seals either between the inner and outer bags or directly inside the inner bag at the discontinuity to help bridge the gap. Eliminating bag bridging avoids channeling and resin rich areas that would develop at the bridged sites.

The process can reduce or essentially eliminate bag mark off with the use of semi-boardy, closely woven, TEFLON impregnated fiberglass materials such as Taconic 7195 or ChemFab CHEMGLAS 1589 as a separate ply and flow media. (page 33, too) The low profile minimizes bulk and allows better contouring relative to several layers of glass cloth materials. The uniform, close weave construction results in more uniform pressure application across the preform relative to knotty knit materials or bag offset materials. The low profile and weave uniformity also makes it possible to use cauls or intensifiers effectively above the flow media to enhance part surface smoothness. The semi-boardy nature of the flow media works to buffer bag and breather wrinkles from transferring to the infused part even in the absence of pressure intensifiers or caul plates. When this flow media is used in conjunction with vacuum thermal cycles, high elongation bags, and gum rubber seals around major discontinuities, mark off is substantially eliminated even on complex parts. Mark off can cause a local weakening of the composite caused by stress concentration.

In our process, an Airweave N-10 breather (63, page 40) between our inner and outer bag has a tendency to bridge over part discontinuities and to fold in areas of excess bulk. To achieve optimum fit between the part and the preform, the breather and the outer bag are placed over the inner bag with vacuum to seat the breather temporarily. The outer bag and the breather are removed. The breather usually is then, cut and darted to allow a perfect fit. The breather, elastomeric materials that form the outer bag, and the breather network can usually be reused.

Therefore, preferred embodiments of our process produce composites with low void content, minimal surface porosity, excellent thickness control, and high fiber volume. The preferred process provides high vacuum integrity, eliminates resin channeling and poor wave front control. It greatly reduces bag side mark off. It reduces the plumbing complexity and improves manufacture of wide composites. Finally, it also reduces resin waste.

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1 and 6 - 8 are rejected under 35 U.S.C. 103(a) as being unpatentable over *Johnson* (U.S. Patent 4,132,755) in view of *White* (U.S. Patent 5,427,725) and in further view of EP 0 816 438 A2 (Cytec), *Shepherd* (U.S. Patent 5,129,813) and *McClure* (U.S. Patent 6,090,335).

Claims 4, 5, and 10 are rejected under 35 U.S.C 103(a) as being unpatentable over *Johnson* (U.S. Patent 4,132,755) in view of *White* (U.S. Patent 5,427,725) and in further view of Cytec (EP 0 816 438 A2), *Shepard* (U.S. Patent 5,129,813), *McClure* (U.S. Patent 6,090,335), and *Imanara* (U.S. Patent 5,364,584).

Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over *Johnson* (U.S. Patent 4,132,755) in view of *White et al.* (U.S. Patent 5,427,725) and in further view of Cytec, *Shepherd* (U.S. Patent 5,129,813), *McClure* (U.S. Patent 6,090,335) and *Stoeberl* (U.S. Patent 4,120,632).

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over *Johnson* (U.S. Patent 4,132,755) in view of *Stoeberl* (U.S. Patent 4,120,632).

7. ARGUMENT

Rejections based upon §103(a)

Claims 1, 4 - 8, and 10 - 12 are rejected under §103(a) as being obvious. The Examiner has overlooked or ignored many claimed features and the combination of those features, and their unique combination into the claimed process.

The references individually or collectively fail to describe a process that uses two vacuum bags, for vacuum integrity and control of bag relaxation, made from a material that also resists wrinkling in combination with a flow media of the specified characteristics to provide control of the flow front. Control of the flow front and laminate quality are key factors for making aerospace-grade composites, which is the goal of the claimed process. For example, reference teaches or suggests throttling the vacuum lines to achieve a matched mass flow rate, as claim 12 requires. The Examiner simply assumes that the specified condition is obvious despite the absence of any suggestion in the applied references.

Claims 1, 6, 7, & 8 are rejected based upon U.S. Patent 4,132,755 (*Johnson*) in view of U.S. Patent 5,427,725 (*White*) in further view of EP 0 816 438 (Cytec), U.S. Patent 5,129,813 (*Shepherd*) and U.S. Patent 6,090,335 (*McClure*). A skilled artisan would not combine these five references in the manner the Examiner asserts without using hindsight based upon Applicant's own teaching, because these references fail to teach or to suggest the alleged combination. They only are combined because of what Applicant has determined and taught others to do to provide a reliable vacuum-assisted resin infusion process. The claimed invention allows the manufacture of aerospace quality composite parts having a high fiber volume fraction. The Examiner has reconstructed the claimed invention by resort to the Applicant's claims. The references alone do not and would not lead the skilled artisan to the claimed invention. The teachings of the several references actually makes them incompatible in combination, and, accordingly, would lead the skilled artisan away from the present invention.

Johnson describes a process for manufacturing resin-impregnated reinforced articles without the presence of resin fumes. A fiberglass cloth is placed on the mold, a prefabricated material is placed over the cloth, and an impervious flexible material (the vacuum bag) is placed over the perforated material. A vacuum is drawn in the chamber between the vacuum

bag and mold. Resin is introduced into the evacuated chamber between the bag and the perforated material. The resin is distributed evenly into the cloth by flowing through openings in the perforated material without the escape of resin fumes. An adhesive may be sprayed on the cloth to allow it to stick to vertical surfaces.

Johnson does not use two vacuum bags, does not use a tackifier, and does not vacuum debulk a preform. If elements 3 and 4 in *Johnson* are vacuum bags, *Johnson*, then, does not use a flow media.

Johnson does not use open weave flow media, or, as required in step (e), media fill fibers that act as weirs to regulate the infusion of the resin. *Johnson* teaches the use of a porous media with slits to allow resin to flow down into the fiberglass cloth. This is not “open weave flow media” of the nature that Applicant’s claim.

White describes a process for resin transfer molding and a preform used in the process. *White* tackifies a preform to make it shapeable, adds a matrix resin and co-cures the tackifier and resin. *White* does not mention vacuum-assisted resin infusion. Applicant did not invent tackifying, but *White* fails to teach that tackifying can or should be used in a vacuum-assisted resin infusion process. *Johnson* does not suggest without using hindsight, using a tackified perform either, so no one would combine *Johnson* and *White* in the manner that the Examiner has.

The Examiner asserts that it is logical to combine *Johnson* and *White* because *White* teaches that tackified preforms allow making of net shape composites by allowing stacking of individual layers. Of course, neither *Johnson* nor *White* indicate that there is any problem with stacking tackifier-free layers in *Johnson* to make a flat panel, so there is no motivation from either reference to make the change in *Johnson* that the Examiner suggests. *Johnson* is content to make his composites without tackified preforms, especially when *Johnson* does not have any net shaping issues to deal with. *Johnson* and *White* are combined solely because of what Applicant has taught rather than from any logic in the references themselves. The Examiner applies hindsight. Furthermore, Applicant uses a tackifier that toughens the composite to improve its damage tolerance. *White* fails to teach or to suggest such a tackifier. He simply wants the preform layers to stick together during the layup. There is no reason to combine *Johnson* and *White*, but, even if you do, you do not get what Applicant teaches and claims.

Cytec describes tackified prepreg systems that make a toughened composite. Cytec uses a non-toughening, elastomeric tackifier, and, therefore, teaches away from what Applicant describes and claims. Cytec achieves toughening in the composite by using a toughening amount of a particulate engineering thermoplastic blended into the resin and impregnated onto the tackified fabric to form a prepreg. Cytec teaches away from the present invention by suggesting the use of thermoplastic particulates mixed with the resin to achieve the toughening and in teaching the need to use a prepreg rather than a preform. If one were to substitute what Cytec teaches for *White* and to carry that back into *Johnson*, the resin would already be inside the vacuum bags and there would be no need for infusion. Accordingly, no one would combine these references because what they teach clashes. Applicant claims a toughening tackifier. Cytec teaches a non-toughening tackifier in combination with a toughening amount of a particulate engineering thermoplastic. Therefore, no one would combine Cytec, *Johnson* and *White*, because of the incompatible suggestions. The combination would still fail to suggest the steps that Applicant claims. Skilled artisans do not pick isolated, disparate, and conflicting teachings and elements from several references without clear direction that one is a substitute for another or that one will solve a problem understood to plague another.

Here, one reference teaches to use a perform without a tackifier. A second reference teaches a tackifier, but not in the context of a perform for VARTM. The Examiner asserts, nevertheless, that it teaches one to use a tackifier in VARTM. The claimed invention requires a toughened tackifier, so the Examiner resorts to yet a third reference to suggest it. The third reference, however, teaches the use of a non-toughening tackifier. Toughening is provided through a particulate engineering thermoplastic. Applicant does not claim using a tackified perform with a particulate engineering thermoplastic. Applicant claims using a tackified perform with a “tackifier containing toughening agents.” This step is not suggested by the combined suggestions of *Johnson*, *White* and Cytec.

Resin infusion in the present invention is designed to replace the use of prepreps which are expensive to make, expensive to store, and short lived because the resins react while in storage, even when frozen.

Shepherd describes embossed vacuum bag and methods for producing and using the bag. The Examiner asserts that *Shepherd* teaches using a low modulus, high elongation nylon

vacuum bag, and concludes, then, that it is logical to use it in the manner that Applicant claims in conjunction with Cytec, *Johnson* and *White*. Applicant does not claim to have invented low modulus, high elongation vacuum bags. Applicant's invention is a method that uses such bags in combination with other novel elements to produce aerospace composites. The novelty in Applicant's invention resides in the method steps used rather than in Applicant discovering a new material that can be used in a conventional process. *Shepherd* discusses bag relaxation, which is probably why the Examiner cited it. The essential feature of the *Shepherd* bag, to achieve its objects, however, is that it has impressed on it a 3-D pattern which defines a plurality of interconnected channels (col. 2, lines 56 – 61). Applicant does not use such a bag material. The *Shepherd* bag may have the low modulus and high elongation attributes, because it relaxes to form a fully conformal surface over the layup - - *Shepherd* uses prepregs - -, but *Shepherd* fails to cure all the deficiencies of *Johnson*, *White*, and Cytec.

McClure describes a process of forming fiber reinforced composite articles using an in situ cured resin infusion port. It fails to overcome the deficiencies in the rejection that Applicant has raised with respect to *Johnson*, *White*, and the other cited references. The Examiner asserts that *McClure* teaches the use of resin flow media. If that is true, as Applicant pointed out earlier, the skilled artisan would not use the flow media in *Johnson* because *Johnson* creates resin distribution channels in the bagging material and does not want or need flow distribution media. Using flow distribution media in *Johnson* would increase waste and cost, without providing any benefit. Therefore, the Examiner cites *McClure* purely by the application of hindsight based upon Applicant's own teaching. He sees that Applicant claims flow media, so he has found a patent that uses it. It is illogical, however, to use *McClure*'s flow media with *Johnson*'s system insofar as doing so provides two elements to perform the same function when either one alone would do fine.

The Examiner refers to discussion of what *McClure* characterizes as the prior art as *McClure*'s teaching or suggestion to use flow media. The flow media is described as a cloth which tends to wick the resin to facilitate resin flow. *McClure* actually teaches not to use such flow media because it requires labor to place it, specialized procedures for disposal and clean-up, and added time. Further, *McClure* describes a cloth that facilitates flow while Applicant claims a flow media having weirs (i.e. dams) that inhibits flow.

The combination of references asserted by the Examiner fail to teach or to suggest the method steps recited in claims 1, 6, 7, or 8. The cited references do not suggest using a tackifier containing toughening agents. They do not suggest using two, low modulus, high elongation vacuum bags to minimize bag wrinkles. They do not suggest an open weave flow front by having fill fibers act as weirs. They do not suggest a stiff but pliable flow control media to prevent bag side mackoff. They do not together suggest infusing the resin through the flow media. Because the combined references lack all these limitations of claim 1, the rejection for obviousness must be withdrawn.

The rejection should also be withdrawn simply by recognizing that the skilled artisan would never combine teachings from five different references.

With respect to claim 6, the Examiner asserts that *White* tackifies the preform at elevated temperature and, then, impregnates the preform with resin while the preform is hot. Claim 6, however, specifies that the inner vacuum bag is applied when the preform is at an elevated temperature. *White* does not suggest this step. The fact that two steps in the references involve a heated perform tells you nothing about the claimed step of applying the vacuum bag while the perform is heated.

With respect to claim 7, the Examiner asserts that *White* also teaches partially curing the tackifier before infusing resin. Claim 7, however, recites that vacuum debulking occurs at an elevated temperature. *White* does not discuss vacuum debulking so it cannot suggest doing it at an elevated temperature.

The action is confusing because it refers first to *White* and, then, reverts to *Johnson*. *Johnson* does not suggest vacuum debulking, although it does teach evacuating the cavity around the preform prior to introducing resin to avoid entrapping air bubbles in the resin. Of course, if this cavity is evacuated and so, too, is the cavity that holds the spacer, there is no driving force to create the temporary resin distribution channels. Therefore, *Johnson* is internally inconsistent in what it teaches. In any event, it does not teach vacuum debulking at an elevated temperature.

With respect to claim 8, the Examiner asserts that *Johnson* teaches use of carbon fiber and epoxy resin and that *White* teaches an epoxy resin tackifier. The selection of materials, however, does not overcome the deficiencies of all the references with respect to the method steps of claim 1.

Claims 4, 5, and 10 are rejected based upon *Johnson, White, Cytec, Shepherd, McClure*, and U.S. Patent 5,364,584 (*Imanara*). *Imanara* describes a process for producing fiber-reinforced resin moldings, including slanting a mold 15-90 degrees prior to and during resin infusion. The skilled artisan does not combine *six* references.

Claims 4 and 5 depend from claim 1 and are patentable because of the deficiencies already noted with respect to *Johnson, White, Cytec, Sheppard, and McClure*. While *Imanara* suggests tilting the preform, it does not overcome all the other noted deficiencies.

Claim 10 is an independent claim that requires use of an open weave, modest permeability flow control media having fill fibers that act as weirs to resist resin infusion in conjunction with tilting the preform. Applicant has already argued that *Johnson* and the other references cited with respect to claim 1 fail to teach or to suggest such a media or flow control step. *Imanara* teaches structural reaction injection molding (SRIM) in matched dies at high injection pressure. *Imanara* does not use a flow control media, especially one whose purpose is to resist flow of resin. *Imanara* is inapplicable to what claim 10 requires because *Imanara* is SRIM rather than a vacuum-assisted resin transfer molding process. *Imanara* in combination with the other references still fails to teach a flow media with fill fibers acting as weirs to achieve improved control of the resin wavefront in a bagged preform.

Claim 11 is rejected based upon *Johnson, White, Cytec, Shepherd, McClure*, and U.S. Patent 4,120,632 (*Stoeberl*). *Stoeberl* describes molds for producing plastic boats in matched dies. *Stoeberl* teaches “passages [that] are effective to relieve foam that is pumped into the mold cavity between the mold halves..., allowing air to escape from the mold cavity while throttling the air released to build up back pressure or to create a suction effect.” Claim 11 requires throttling the vacuum lines to control the mass flow rate of resin matching the mass flow rate into the cavity with that in the preform. *Stoeberl* fails to teach or to suggest this step. Claim 11 also is patentable because the other references fail to teach or suggest what Applicant recites as the process steps in claim 1, as previously argued.

Claim 12 is rejected for obviousness over *Johnson* in view of *Stoeberl*. Claim 12 requires in a vacuum-assisted resin transfer molding process, throttling the vacuum lines to achieve a mass flow rate of resin into a debulked preform at a rate where the in/through the preform is substantially equal to the rate in the vacuum lines. That is, the throttling means

that resin entering the cavity does not pool or accumulate in the flow media because the same mass that is entering in a period of time is the same mass that is infusing into the preform.

Johnson does not teach a debulked preform. *Johnson* does not throttle infusing resin in the feedlines. It feeds the resin directly into the cavity around the fiberglass cloth. *Johnson* fails to teach or to suggest what Applicant claims in claim 12.

Stoeberl teaches throttling to create a back pressure. *Stoeberl* does not discuss equilibrating the mass flow rate into the cavity with that in the preform. *Stoeberl* does not have flow media where pooling could occur and only has fibrous sheets on the surfaces of the mold cavity rather than as a preform. The body of *Stoeberl's* boat is largely unreinforced.

Accordingly, *Stoeberl's* throttling does not overcome the deficiencies of *Johnson* and the combined references fail to teach or to suggest the invention of claim 12.

8. CLAIMS APPENDIX

The appealed claims are:

1. A vacuum-assisted resin transfer molding process for making a laminate, comprising the steps of:
 - (a) assembling a preform from suitable reinforcement, in a mold;
 - (b) tackifying the preform with a tackifier containing toughening agents for improved damage tolerance in the mold to produce a tackified preform;
 - (c) vacuum debulking the tackified preform;
 - (d) double bagging the debulked preform with an inner bag and outer bag using high elongation, low modulus nylon bagging films sufficient to control bag relaxation and to improve vacuum integrity while minimizing bag wrinkles;
 - (e) enclosing an open weave flow control media between the inner bag and the debulked preform to control the flow front during resin infusion, the flow media having permeability to control the infusion flow and to create flow resistance by using fill fibers to act as weirs to an infusing resin, wherein the flow media also is able to withstand exposure to temperatures up to about 600°F, is chemically inert, and is sufficiently

stiff and pliable to eliminate markoff on the bag side of the laminate;
and

- (f) infusing resin into the debulked preform through the flow media using a vacuum-assisted resin transfer molding process using a series of vacuum ports spaced around the perform.

4. The improvement of claim 1 wherein the step of infusing the resin includes fitting the preform tilted at an angle off horizontal.

5. The process of claim 1 wherein infusion occurs with at least a portion of the preform tilted at an angle off horizontal so that gravity at least partially opposes flow of the resin into the preform.

6. The process of claim 1 wherein the inner bag is applied to the preform at an elevated temperature.

7. The process of claim 1 wherein vacuum debulking occurs at an elevated temperature to better bind the tackified preform together.

8. The process of claim 1 wherein the reinforcement is carbon fiber, the tackifier is a plasticized epoxy, and the resin is epoxy.

10. An improved vacuum-assisted resin transfer molding process for infusing resin into a preform, the improvement comprising:

introducing resin to a flow media at the lowest point in the bagged preform assembly so that infusing resin flows against gravity through the flow media and preform, thereby providing improved control of the wavefront by higher resistance to flow than with horizontal infusion, the flow media having an open weave, having permeability reduced by including fill fibers that act as weirs to the infusing resin, wherein the flow media also is able to withstand exposure to temperatures up to about

600°F, is chemically inert, and is sufficiently stiff and pliable to eliminate markoff on the bag side of the laminate.

11. The process of claim 1 further comprising the step of throttling vacuum lines connected in fluid communication with the double bagging so that the mass flow rate of resin through the debulked preform substantially equals the mass flow rate of resin in the vacuum lines.

12. In a vacuum-assisted resin transfer molding process, the improvement comprising:

throttling vacuum lines connected in fluid communication with double bagging surrounding a debulked preform so that the mass flow rate of resin through the debulked preform substantially equals the mass flow rate of resin in the vacuum lines.

9. EVIDENCE APPENDIX

None submitted


10. RELATED PROCEEDINGS APPENDIX

Not applicable

CONCLUSION

Claims 1, 4-8, and 10-12 should be allowed.

Respectfully submitted,


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